# Weather Note

## UNUSUAL WAVE CLOUD OVER WASHINGTON, D. C., NOVEMBER 30, 1959

DEVER COLSON AND CHARLES V. LINDSAY

U.S. Weather Bureau, Washington, D.C.

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The striking and spectacular wave cloud formation shown in the accompanying photograph (fig. 1) appeared over Washington, D.C., on November 30, 1959. These clouds persisted from about 1100 to 1500 EST. There were several pilot reports of turbulence and downdrafts over the general area during this period.

The base of the clouds was estimated at between 10,000 and 12,000 feet above sea level. The orientation of the long bands was from about 230° extending toward 50°. The long wave bands were estimated by pilots to be between 4 and 5 miles apart. Pilots reported that the wave bands extended all the way back to the mountains west of Washington. At least nine separate wave bands can be observed in the photograph. These clouds were nearly stationary except for a slight drift of the entire cloud system downwind.

An inspection of the morning sounding taken at Washington, D.C. (fig. 2), shows a nearly adiabatic layer from 680 to 620 mb. and a layer above the 600-mb. level with a lapse rate of about 0.7 the dry adiabatic rate. These layers are separated by a stable layer with a 1° C. inversion between 620 and 600 mb. The winds were from about 310° and the speeds were about 40 knots (20 m. sec.$^{-1}$) in the lower layer and 65 knots (33 m. sec.$^{-1}$) in the upper layer. The sounding shows very dry air from 5,000 to nearly 10,000 feet.

Unfortunately, there is no radiosonde report for 1300 EST. However, the 1300 EST upper-level winds showed little change from the 0700 EST winds, and it is assumed that the temperature at 1300 EST was similar to that at 0700 EST. Using a mean temperature lapse rate of 0.8 times the dry adiabatic for the two layers, with a 1° A. temperature inversion between the layers, a mean temperature of 255° A., and a wind speed difference across the boundary of 13 m. sec.$^{-1}$, in the equations developed by Haurwitz [1, 2] for billow clouds gives a wavelength of 4.5 km. (2.8 mi.). If it is assumed that the lapse rate steepened slightly during the morning to a temperature lapse rate of about 0.9 times the dry adiabatic, the computed wavelength becomes 6 km. (4 mi.). These results appear to be in reasonable agreement with the observed data.

Work on wave clouds by Colson [3], indicates the need for the presence of a strong wind shear and a stable layer. The main axis of the jet stream in this case appears to have been just to the south, giving strong winds and wind shear over the Washington area. There was a definite stable layer near the 12,000-ft. level (fig. 2).

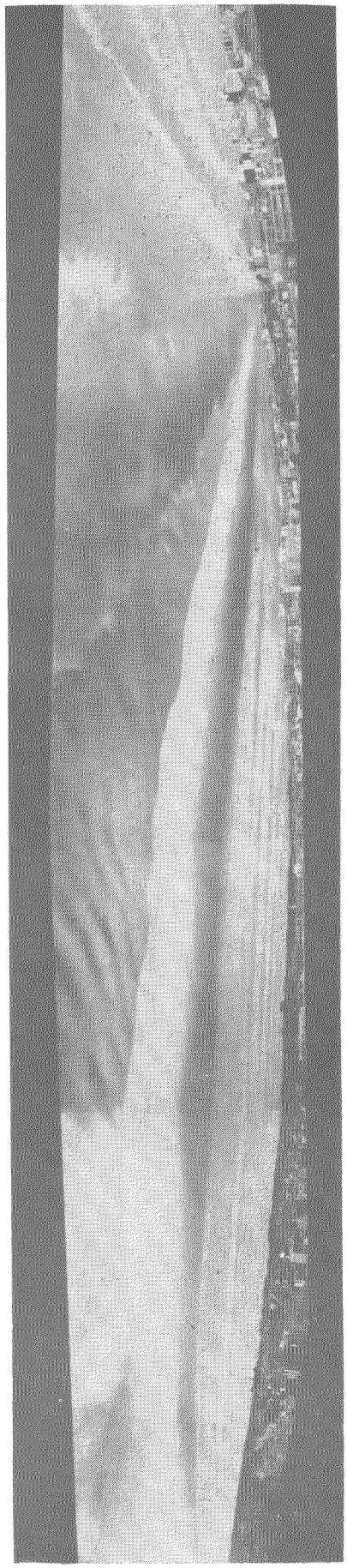

FIGURE 1.—The series of wave clouds over the Washington, D.C., area on November 30, 1959. Photograph is a composite of a series of photographs taken by E. Orr, U.S. Weather Bureau, from the roof of the Weather Bureau building at 24th and M Streets N.W. in Washington. The view is from the west through north to east (left to right).

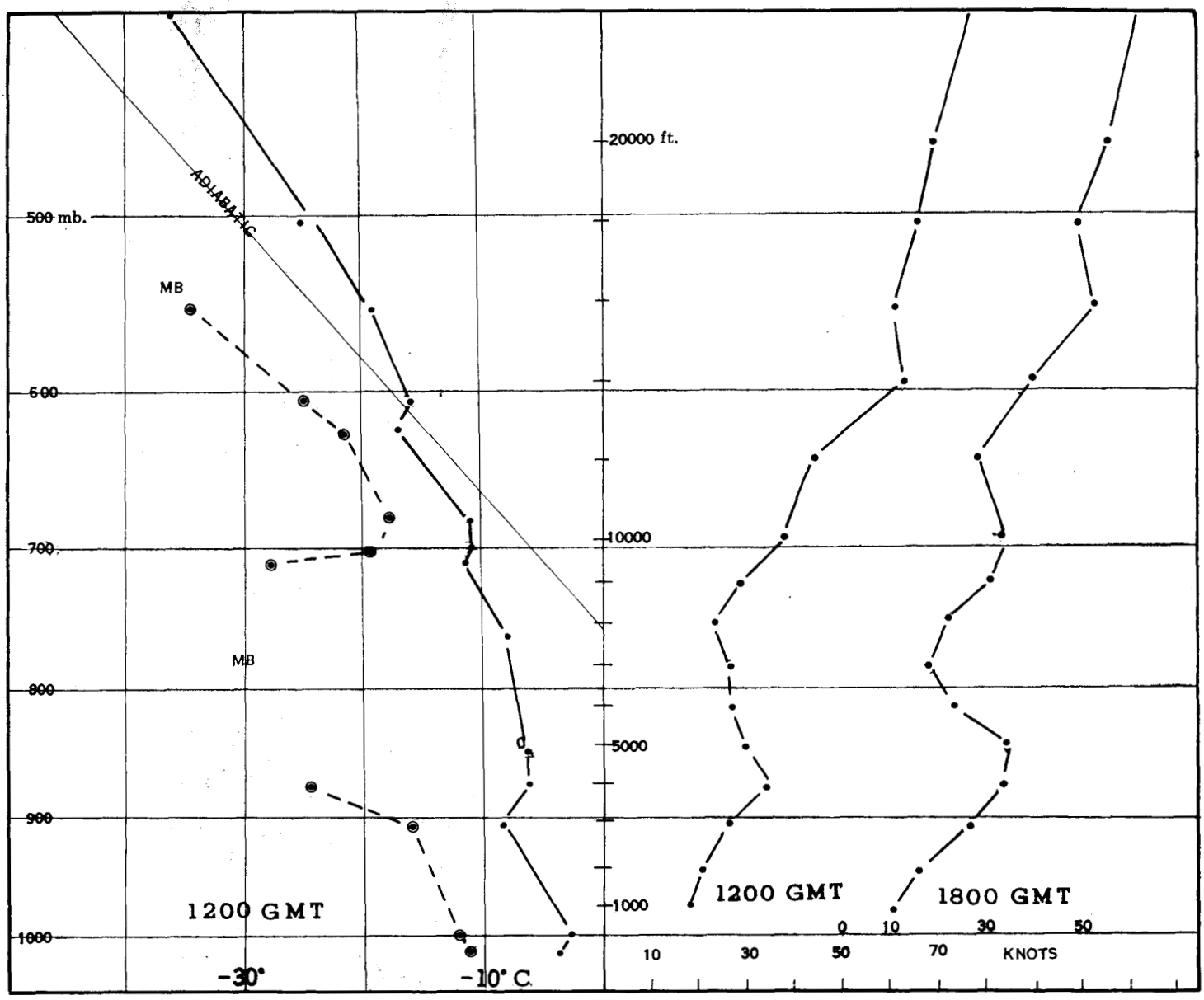


FIGURE 2.—Washington, D.C., November 30, 1959. Upper-air sounding for 1200 GMT and winds for 1200 and 1800 GMT.

Work by Scorer [4] shows the importance of the stability term $l^2=g\beta/U^2$ in the establishment of waves, where $\beta$ is the static stability and $U$ is the wind speed. According to Scorer, the value of the quantity $l^2$ should decrease in the upper layer over that in the lower layer. In this case, $l^2$ showed a value of between 2 and 4 below 12,000 ft. and from 0.1 to 0.3 above that level.

During this period, the barograph showed a decrease in pressure between 1000 and 1400 EST which was in excess of the normal diurnal fall. A study of the high-speed barograph trace for this date showed a series of about five separate decreases in pressure between these hours. This would correspond to a drift of about 4–5 m.p.h. of the entire wave pattern.

During the latter part of the afternoon, the cloud pattern dissipated and became quite indistinct by evening. The evening radiosonde report showed a definite increase in moisture in the intermediate layers. There was still a broad inversion of about 2° A. between 5,000 and 6,000 feet. The wind speed difference was from 10 m. sec.$^{-1}$ below the broad inversion to 20 m. sec.$^{-1}$ above it.

Work is continuing on the occurrence of wave clouds over the general Washington area for the entire winter season.

REFERENCES

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2. B. Haurwitz, "Wogenwolken und Luftwogen," *Meteorologische Zeitschrift*, vol. 48, 1931, pp. 483–484.
3. D. Colson, "Meteorological Problems in Forecasting Mountain Waves," *Bulletin of the American Meteorological Society*, vol. 35, No. 8, October 1954, pp. 363–371.
4. R. S. Scorer, "Forecasting Dangerous Flying Conditions near Mountains," Great Britain, Meteorological Research Committee, *M.R.P. 814*, May 23, 1953.